Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

SHORTER ARTICLES AND DISCUSSION

BARRIERS TO DISTRIBUTION AS REGARDS BIRDS AND MAMMALS

THE geographical range of any species of animal may be likened to a reservoir of water in a mountain canyon. The confining walls are of varying nature. A concrete dam, absolutely impervious, may retain the water at one end. Along either side the basin's walls differ in consistency from place to place. The substratum varies in porosity, at some points being impervious like the dam, at others permitting of seepage of water to a greater or less distance from the main volume. The water continually presses against its basin walls, as if seeking to enlarge its area. And it may succeed in escaping, by slow seepage through such portions of its barrier as are pervious or soluble, or by free flow through a gap in the walls, if such offers. The area occupied by the water will extend itself most rapidly along the lines of least resistance.

Every species has a center or centers of abundance in which favoring conditions usually give rise to a rate of reproduction more than sufficient to keep the critical area stocked. A tendency to occupy a larger space results, because of competition within the species: individuals and descent-lines multiply and travel radially, extending those portions of the frontier where least resistance is offered. Such radial dispersal takes place slowly in some directions, more rapidly in others, according to the degree of passability of the opposing barriers. These barriers consist of any sort of conditions less favorable to the existence of the species than those in the center of abundance.

Theoretically, sooner or later and in all directions, every species is absolutely stopped. But as a matter of undoubted fact most barriers are continually shifting, and the adaptability of the animals themselves may be also undergoing continual modification; so that perfect adjustment is beyond the limits of possibility so long as topography and climate keep changing. The ranges of species may thus be constantly shifting. Descent-lines may move about repeatedly over the same general region, like sparks in the soot on the back of a brick fireplace.

Yet, in all of our studies, of but a few years' duration, the time element is reduced almost to a negligible quantity, and we may look upon the areas occupied by each species as, for the time of our observation, fixed. We are thus enabled to compare one with another, and because of the large number of the species, we can infer a good deal as to the nature of barriers in general, at least as regards birds and mammals. It is even conceivable that; with sufficient refinement in methods, the inquirer might in time find himself able, from a comparative study of the ranges of rodents, for example, to establish the identity of all of the external factors which have to do with the persistence of each of the species; in other words to analyze the "environmental complex" into its uttermost elements—as regards the existing species of rodents in their recent development.

The most obvious kind of barrier to distribution is that consisting of any sort of physical, or mechanical, obstruction. Such obstruction affects directly the *individuals* of a species encountering it, either by stopping their advance or by destroying outright such as attempt to cross it. As barriers of this nature, are to be cited land in the case of purely aquatic mammals, and bodies of water to purely terrestrial, especially xerophilous, mammals. In each case the width of the barrier has to do with the degree of impassability. Oceans and continents are most perfect, and affect a large proportion of the species. The comparatively narrow Colorado River is a barrier of the first rank, but only to a certain few desert rodents. Mechanical barriers, where they exist at all, are clearly recognizable.

It is to be observed, however, upon considering the birds and mammals of a whole continent, that by far the greater number of species are delimited in range without any reference to actual land and water boundaries; more explicitly, their ranges fall far short of coast lines. The barriers here concerned are intangible, but nevertheless powerful. By their action the spread of species, genera and families is held in check as surely as by any tangible obstruction.

By these invisible barriers the *individual* may not necessarily be stopped at all, as with animals of free locomotion; but the *species* is affected. For example, the mocking bird in its Californian distribution is closely confined to those parts of the state possessing certain definite climatic features; but vagrant individuals, especially in autumn, occur far beyond the limits of these restrictive conditions. Carnivorous mammals are well known to be subject to sporadic wanderings on the part of individuals, but the *species* is kept in set bounds by some potent but invisible set of factors. The very fact that *individuals* are quite capable of temporarily transgressing these bounds and yet do not overstep them *en masse* emphasizes all the more the remarkable potency of this category of barriers as regards species and higher groups.

Our geographic studies lead us to designate among these relatively intangible barriers: (1) increase or decrease in prevailing temperature beyond certain critical limits, according to the species concerned; (2) increase or decrease in prevailing atmospheric humidity beyond certain limits; (3) modification in food-supply and appropriate breeding and foraging ground. The limits set by each of these factors will vary with the physiological peculiarities of the organism considered; in other words the inherent structural equipment of each animal figures importantly. In these three sorts of barriers will be recognized what have been called *''zonal,'' ''faunal''* and *''associational''* delimitation, each of which I will now try to define.

Two schools of faunistic students are represented among American zoo-geographic writers of the present day. One, of which C. H. Merriam is the most prominent exponent, sees in temperature the chief cause controlling distribution, and deals with the ranges of species in terms of ''life zones.'' The other school, of which C. C. Adams, A. G. Ruthven and Spencer Trotter are active advocates, assigns to temperature but a minor rôle, looking rather to a composite control, of many factors, resulting in ecologic ''associations,'' of which plants are essential elements, and which are to be further explained on historical grounds. The two sets of areas thus defined do not by any means correspond. Yet the reviewer can not fail to note, here and there, places where boundaries coincide, and such coincidences are so frequent as to be suggestive of real concordance in some significant manner. Is it not probable that both schools are approximately correct, the difference in mode of treatment being due to different weights given the different kinds of evidence, or, in other words, to difference in perspective?

Every animal is believed to be limited in distribution zonally by greater or less degree of temperature, more particularly by that of the reproductive season. When a number of animals (always in company with many plants similarly restricted) approximately agree in such limitation they are said to occupy the same life zone.

The observation of this category of distributional delimitation is particularly easy in an area of great altitudinal diversity like that comprised in the southwestern United States. The writer is led to wonder if those authors who minimize the importance of temperature have ever been privileged to travel extensively, and *carry on field studies,* outside of the relatively uniform eastern half of North America!

Study of any area which varies widely in altitude and hence provides readily appreciable differences in daily temperature from place to place brings conviction of the very great effectiveness of temperature in delimiting the ranges of nearly all species of animals as well as of plants. Particular attention may be called to the pertinent results of Merriam's survey of Mount Shasta.

But temperature is not to be considered the only delimiting factor of environment, though its possible overemphasis by the Merriam school seems to have led some other persons to believe that this view is held. In fact it becomes evident, after a consideration of appropriate data, that very many species are kept within geographic bounds in certain directions only by an increasing or decreasing degree of atmospheric *humidity.* By plotting the ranges of many animals as well as of plants coincidence in this regard is found in so many cases as to warrant the recognition of a number of "faunal areas"—on the causative basis of relative uniformity in humidity. It is probable that every species is affected by both orders of geographic control.

The reader may enquire as to the grounds for employing the widely used terms zone and fauna in the restricted sense here prescribed. In reply, it may be said that this is not an innovation, but is an adoption of a usage which has come about historically among a certain group of workers in the geography of vertebrate animals in North America. The writer recognizes the fault in imposing restricted meanings upon old terms, but he also hesitates at coining new words.

As to which is *the more* important, assembled data seem to show that more genera and higher groups are delimited by zonal boundaries than by faunal boundaries. The arresting power of temperature barriers would therefore seem to be relatively the greater.

In the third category of distributional control there is a conspicuous association of the majority of so-called adaptive structures of animals (often of high taxonomic value) with certain mechanical, or physical, features of their environment. An animal may thus intimately depend upon certain inorganic or organic peculiarities, or both, of a given area, and be unable to maintain existence beyond the limits of occurrence of those features of the environment. Tracts of relatively uniform environmental conditions, including their inanimate as well as living elements, are here called *associations*.

After a consideration of all the birds and mammals occurring both within the state of California and elsewhere as far as the writer's knowledge goes, associational restriction appears to be governed by the following three factors, of relative importance in the order named.

1. Kind of food-supply afforded, with regard to the inherent structural powers of each of the animals concerned to make it available.

2. Presence of safe breeding places, adapted to the varying needs of the animals, in other words depending upon the respective inherent powers of construction, defence and concealment in each species concerned.

3. Presence of places of temporary refuge for individuals, during daytime or nighttime, or, while foraging, when hard-pressed by predatory enemies, again correlated with the respective inherent powers of defence and concealment of each species involved.

It is believed that the geographical distribution of any animal is correctly diagnosed in terms of each of the three main groupings here suggested. In other words an animal belongs simultaneously to one or more zones, to one or more faunas, and to one or more associations. No one of these groupings can be stated in terms of the other, any more than a person can compute liquids by candle-power, or weight in miles. The constituent species within each of these groupings always belong to the other two. To illustrate: the southern white-headed woodpecker inhabits the coniferous forest association of the San Bernardino fauna of the Transition zone; the Abert towhee belongs to the mesquite and the quail-brush associations of the Colorado Desert fauna, of the Lower Sonoran zone; the Pacific shrew belongs to the upland riparian association of the northern coast redwood fauna of the Transition and Boreal zones.

Classification of Barriers to Species as Regards Birds and Mammals

Barriers:

- *A*. Intangible.
  - (*a*′) Zonal (by temperature).
  - (*b*′) Faunal (by atmospheric humidity).
  - (*c*′) Associational.
    - (1) By food supply.
    - (2) By breeding places.
    - (3) By temporary refuges.
      (Each of these three with regard to the inherent structural characters of each species concerned.)
- *B*. Tangible (mechanical).
  - (*a*″) Land to aquatic species.
  - (*b*″) Bodies or streams of water to terrestrial species.

The above categories are believed to include all the factors commonly involved in checking the spread of species of birds and mammals. It is possible that inter-specific competition may sometimes occur where associational homologues meet. But even here it becomes a matter of relative associational fitness which determines supremacy and consequent ultimate limits of invasion of the forms concerned.

A mountain range, mechanically speaking, is no barrier at all, *per se,* as frequently alleged. Only as it involves zonal or faunal barriers does it affect distribution. The same is true of a valley or a desert.

As far as contemplation of cases has gone, the writer's experience has led him to believe that the outlines of the ranges of all birds and mammals may be accounted for by one or more of the factors indicated in the analysis here presented. And as detailed knowledge of the facts of geographical distribution accumulates, the delimiting factors become more and more readily detectable. By such a study, of *comparative distribution,* it seems possible that the ranges of birds and mammals may become subject to satisfactory explanation.

When considered in its historical bearing, the problem of barriers concerns itself intimately with the origin of species. It is believed by the writer that only through the agency of barriers is the *multiplication of species,* in birds and mammals, brought about.

The present contribution is abbreviated from a general discussion of certain distributional problems which forms part of a paper to appear from the University of California press and which treats in detail of the birds and mammals of the lower Colorado Valley, in California and Arizona.

JOSEPH GRINNELL

MUSEUM OF VERTEBRATE ZOOLOGY,
UNIVERSITY OF CALIFORNIA

YELLOW VARIETIES OF RATS

IN a recent number of the NATURALIST I described a yellow variety of the common rat (*Mus norvegicus*) which in recent years made its appearance in England and is now a recognized variety among fanciers. Dr. John C. Phillips and Professor L. J. Cole have both called my attention to a fact which I had overlooked; namely, the occurrence of a yellow variety in another species of rat (*Mus rattus*). Bonhote described the occurrence of this variety in Egypt in 1910 and has since found by experiment (1912) that the yellow variation of *Mus rattus* is recessive in heredity precisely as it is in *Mus norvegicus*. The fact that the yellow variation in mice is dominant in heredity, but can not be obtained in a homozygous condition, stands, therefore, as a phenomenon all the more singular and striking.

W. E. CASTLE.

BUSSEY INSTITUTION,
March 3, 1914.